IN THE CLAIMS

Claim 57 is amended.

The following is a claim listing showing all pending claims:

1. (Previously Presented) A microcomponent apparatus for conducting unit operations comprising:

a microcomponent device comprising a first inlet, first exit, a first array of microchannels, and a second array of microchannels;

wherein, during operation, a stream enters the first inlet of the microcomponent device and is distributed among said first array of microchannels and a first unit operation is performed on said stream, said stream exiting through the first exit and exiting the microcomponent device;

a processing device connected to the first exit of the microcomponent device; said processing device being capable of modifying said stream by a second unit operation;

an outlet of the processing device connected to a second inlet of said microcomponent device through a second inlet; and

the second array of microchannels connected to said second inlet and a second exit connected to said second array of microchannels;

wherein, during operation, said stream re-enters said microcomponent device and is distributed among the second array of microchannels where said first unit operation can again be performed on the stream, and said stream exits through the second exit and exits the microcomponent device.

2. (Original) A microchannel device comprising:

a first zone, wherein during operation, at least one unit process operation is performed, and that, during operation, functions at a first temperature;

a second zone that, during operation, functions at a second temperature;

wherein the first temperature is different than the second temperature; and

a microchannel heat exchanger that is disposed between the first zone and the second

zone; and

wherein, during operation, a stream flows from the second zone through the microchannel heat exchanger to the first zone and subsequently flows back through the microchannel heat exchanger to the second zone;

wherein, during operation, within the microchannel heat exchanger, heat is exchanged between the stream flowing from the second zone to the first zone and the stream flowing from the first zone to the second zone; and

wherein the heat exchanger has a thermal power density of at least 0.6 W per cubic centimeter and an exergetic efficiency of at least 80%.

3. (Original) The microchannel device of claim 2 wherein the heat exchanger has an exergetic efficiency of at least 80% when the first zone is at a temperature of 600°C and the second zone has a temperature of 200°C.

4. (Original) The microchannel device of claim 3 wherein the first zone comprises a chemical reactor.

5 (Original) The microchannel device of claim 2 wherein, during operation, the temperature of the first zone and the temperature of the second zone differ by at least 350°C.

6. (Original) A microstructure architecture comprising at least two layers:

a first layer comprising a continuous flow microchannel;

a second layer adjacent said first layer and comprising at least one flow microchannel;

wherein said first layer and said second layer cooperate to form at least two unit operations; and

wherein said continuous flow microchannel forms at least a portion of said at least two unit operations.

7. (Original) The microstructure architecture of claim 6 wherein the flow microchannel is substantially straight.

8. (Original) The microstructure architecture of claim 6 wherein said flow microchannel forms at least a portion of at least three unit operations.

9. (Previously Presented) The microstructure architecture of claim 6 comprising at least three adjacent flow microchannels; wherein said microchannels have a width that is defined by microchannel walls; and wherein said microchannel walls have gaps that allow pressure to equalize among the microchannels.

10. (Original) The microstructure architecture of claim 6 further comprising a third layer comprising a continuous flow microchannel;

wherein said third layer is adjacent said second layer;

wherein said third layer and said second layer cooperate to form at least two unit operations; and

wherein said flow microchannel forms at least a portion of at least two unit operations.

11. (Original) The microstructure architecture of claim 10 further comprising a fourth layer comprising a microchannel; wherein

said third layer is adjacent said fourth layer;

wherein said third layer and said fourth layer cooperate to form at least two unit operations; and

wherein said flow microchannel forms at least a portion of at least two unit operations.

12. (Original) The microstructure architecture of claim 11 wherein said first layer and said third layer are structurally identical; and wherein said second layer and said fourth layer are structurally identical.

13-20. (canceled)

21. (Original) A method of exchanging heat in a microchannel device, comprising:

providing a first stream in a microchannel that exchanges heat with a second stream, wherein the first stream remains in the microchannel and, subsequently, the first stream exchanges heat with a third stream without leaving the microchannel.

22. (Previously Presented) A method of conducting unit operations in microcomponent apparatus comprising:

performing a first unit operation on a first stream in a first microcomponent device, subsequent to the first unit operation, performing a second, discrete unit operation on the first stream to make a modified stream, then in a second microcomponent device, performing the first unit operation on the modified stream, to accomplish a single unit operation for the same purpose as the a first unit operation on the first stream.

23. (Original) The microcomponent apparatus of claim 1 wherein the processing device comprises a chamber having a gas inlet for the addition of gaseous components.

24. (canceled)

25. (Previously Presented) The method of claim 22 where the first stream comprises a heat exchange fluid and the first unit operation in a microcomponent device comprises heat exchange, with heat being transferred from the first stream to provide heat for an endothermic process;

wherein the second unit operation modifying first stream comprises reheating said first fluid by reheating from a heat source or by adding additional fuel or oxygen and performing

combustion reactions.

26. (Original) The method of claim 25 where the endothermic process is an endothermic chemical reaction.

27. (Original) The method of claim 25 where the endothermic process comprises a drying or desorption process.

28. (Original) The method of claim 25 where the endothermic process comprises boiling or evaporation.

29. (Original) The method of claim 22 where the first stream is a heat exchange fluid and the first unit operation in a microcomponent cell comprises heat exchange, with heat being transferred from an exothermic process to a first stream to provide cooling; and

wherein the second unit operation modifying first stream comprises cooling said first fluid by transferring heat to a heat sink.

30. (Original) The method of claim 29 where the exothermic process comprises an exothermic chemical reaction.

31. (Previously Presented) The method of claim 29 where the exothermic process comprises a sorption process selected from the group consisting of transforming a gas into a liquid or transforming a gas onto a solid.

32. (Original) The process of claim 31 where the exothermic process comprises a phase change process.

33. (Original) The process of claim 22 where the first stream is comprised of

chemical reactants and the first unit operation in a microcomponent cell comprises a chemical conversion reaction;

wherein the second unit operation modifying first stream comprises mass transfer, with at least one original reactant being added to the first stream.

34. (Original) The process of claim 33 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises adding additional hydrocarbon reactant to first stream.

35. (Previously Presented) A method of conducting unit operations in microcomponent apparatus comprising:

performing a first unit operation on a first stream in a first microcomponent cell, subsequent to the first unit operation, performing a second, discrete unit operation on the first stream to make a modified stream, then in a second microcomponent cell, performing the first unit operation on the modified stream, to accomplish a single unit operation for the same purpose as the a first unit operation on the first stream, where the first stream is comprised of chemical reactants and the first unit operation in a microcomponent cell comprises at least one chemical conversion reaction; and

wherein the second unit operation modifying first stream comprises a chemical separation, with at least one reaction product being preferentially removed from first stream.

36. (Original) The process of claim 35 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises removing hydrogen preferentially using a gas membrane system.

37. (Original) The process of claim 35 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises removing hydrogen preferentially using a sorption process.

38. (Original) The process of claim 35 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises removing hydrogen preferentially using cryogenic distillation.

39. (Original) The process of claim 35 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises removing hydrogen preferentially using a semipermeable membrane in an electrochemical cell.

40. (Original) The process of claim 35 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises a combination of a water gas shift reactor and hydrogen separation.

41-49. (canceled)

50. (Previously Presented) The apparatus of claim 23 wherein the processing device comprises a microchannel reactor having reactor channels interleaved with heat exchange channels.

51. (Previously Presented) The apparatus of claim 50 wherein the processing device comprises a steam reformer.

52. (Previously Presented) The apparatus of claim 51 wherein the apparatus comprises plural steam reformers wherein each of the steam reformers is connected to a recuperator such that, during operation, a stream of fuel and steam passes from the recuperator to a steam reformer and such that, during operation, a stream of reformate passes from the steam reformer back to the recuperator.

53. (Previously Presented) The apparatus of claim 52 further comprising plural combustors that, during operation, provide heat to the plural reformers.

54. (Previously Presented) The apparatus of claim 1 wherein the microcomponent device is a recuperator.

55. (Previously Presented) The apparatus of claim 1 comprising plural pairs of microcomponent devices and processing devices, wherein each pair comprises a microcomponent device and a processing device connected in the manner described in claim 1.

56. (Previously Presented) The apparatus of claim 50 wherein the microchannel reactor comprises more than 10 alternating layers of heat exchangers and reaction channels.

57. (Currently Amended) The apparatus of claim 50 comprising a layer with the reaction channels and a layer with the heat exchange channels; wherein the heat exchange layer and the layer with the reaction channels each have a thickness of 0.1 to 2 mm.

58. (Previously Presented) A method of conducting unit operations in a microcomponent apparatus comprising:

passing a stream into a first inlet of a microcomponent device, wherein the microcomponent device comprises a first inlet, first exit, a first array of microchannels, and a second array of microchannels;

wherein the stream is distributed among said first array of microchannels and a first unit operation is performed on said stream, said stream exiting through the first exit and exiting the microcomponent device;

passing the stream into a processing device connected to the first exit of the microcomponent device; and in said processing device, modifying the stream by a second unit

operation;

wherein the stream exits through an outlet of the processing device connected to a second inlet of said microcomponent device; and

wherein said stream then re-enters said microcomponent device through the second inlet and is distributed among a second array of microchannels where said first unit operation is again performed on the stream, and wherein said stream exits through a second exit connected to said second array of microchannels and exits the microcomponent device.

59. (Previously Presented) The method of claim 58 wherein the processing device comprises a microchannel reactor having reactor channels interleaved with heat exchange channels, and wherein said second unit operation comprises a chemical reaction.

60. (Previously Presented) The method of claim 59 wherein the processing device comprises a steam reformer and the chemical reaction produces hydrogen.

61. (Previously Presented) The method of claim 59 wherein the apparatus comprises plural steam reformers wherein each of the steam reformers is connected to a recuperator and a stream of fuel and steam passes from the recuperator to a steam reformer and a stream of reformate passes from the steam reformer back to the recuperator.

62. (Previously Presented) The method of claim 58 wherein the second unit operation comprises pumping or compressing.

63. (Previously Presented) The method of claim 58 wherein the microcomponent device is a recuperator.

64. (Previously Presented) The method of claim 58 wherein the apparatus comprises plural pairs of microcomponent devices and processing devices, wherein each pair comprises a

microcomponent device and a processing device connected in the manner described in claim 1, and wherein, in each pair, a stream passes from a microcomponent device to a processing device, exits the processing device and passes back into the microcomponent device.

65. (Previously Presented) The method of claim 58 further comprising a step of combusting fuel in a combustor to form a combusted stream, and further comprising a step of passing the combusted stream into the processing device.

66. (Previously Presented) The method of claim 65 further comprising a step of passing the combusted stream from the processing device to a second combustor;

adding fuel into the second combustor and conducting a second step of combusting a fuel to form a second combusted stream;

passing the second combusted stream into a second processing device; and further comprising

passing a second stream into a first inlet of a second microcomponent device, wherein the second microcomponent device comprises a first inlet, first exit, a first array of microchannels, and a second array of microchannels;

wherein the second stream is distributed among said first array of microchannels and the first unit operation is performed on said second stream, said second stream exiting through the first exit of the second microcomponent device and exiting the second microcomponent device;

passing the second stream into a second processing device connected to the first exit of the second microcomponent device; and in said second processing device, modifying the stream by the second unit operation;

wherein the second stream exits through an outlet of the second processing device connected to a second inlet of said second microcomponent device; and

wherein said stream then re-enters said second microcomponent device through its second inlet and is distributed among the second array of microchannels of the second microcomponent device where said first unit operation is again performed on the stream, and wherein said stream

exits through a second exit connected to said second array of microchannels of the second microcomponent device and exits the second microcomponent device.

67. (Previously Presented) The method of claim 59 further comprising a step of combusting fuel in a combustor to form a combusted stream, and further comprising a step of passing the combusted stream into the microchannel reactor to provide heat to an endothermic reaction.

68. (Previously Presented) The method of claim 67 further comprising a step of passing the combusted stream from the processing device to a second combustor;

adding fuel into the second combustor and conducting a second step of combusting a fuel to form a second combusted stream;

passing the second combusted stream into a second processing device; and further comprising

passing a second stream into a first inlet of a second microcomponent device, wherein the second microcomponent device comprises a first inlet, first exit, a first array of microchannels, and a second array of microchannels;

wherein the second stream is distributed among said first array of microchannels and the first unit operation is performed on said second stream, said second stream exiting through the first exit of the second microcomponent device and exiting the second microcomponent device;

passing the second stream into a second processing device connected to the first exit of the second microcomponent device; and in said second processing device, modifying the stream by the second unit operation;

wherein the second stream exits through an outlet of the second processing device connected to a second inlet of said second microcomponent device; and

wherein said stream then re-enters said second microcomponent device through its second inlet and is distributed among the second array of microchannels of the second microcomponent

device where said first unit operation is again performed on the stream, and wherein said stream exits through a second exit connected to said second array of microchannels of the second microcomponent device and exits the second microcomponent device.

69. (Previously Presented) The microchannel device of claim 2 wherein the heat exchanger has an exergetic efficiency of at least 85% when the first zone is at a temperature of 600°C and the second zone has a temperature of 200°C.

70. (Previously Presented) A method of conducting unit operations in a microchannel device comprising:

performing at least one unit process operation in a first zone at a first temperature;

performing at least one unit process operation in a second zone at a second temperature;

wherein the first temperature is different than the second temperature; and

wherein a microchannel heat exchanger is disposed between the first zone and the second zone; and

wherein a stream flows from the second zone through the microchannel heat exchanger to the first zone and subsequently flows back through the microchannel heat exchanger to the second zone;

wherein within the microchannel heat exchanger, heat is exchanged between the stream flowing from the second zone to the first zone and the stream flowing from the first zone to the second zone; and

wherein the heat exchanger has a thermal power density of at least 0.6 W per cubic centimeter and an exergetic efficiency of at least 80%.

71. (Previously Presented) The method of claim 70 wherein the first zone comprises a chemical reactor.

72. (Previously Presented) The method of claim 71 wherein the temperature of the first

zone and the temperature of the second zone differ by at least 350°C.

73. (Previously Presented) The microstructure architecture of claim 10 wherein the first unit operation comprises heating reactants; the second unit operation comprises vaporizing a fuel; and the third unit operation comprises heating water.

74. (Previously Presented) The microstructure architecture of claim 6 wherein each of the layers has a thickness of between 0.1 and 1 mm.

75. (Previously Presented) The microstructure architecture of claim 10 wherein each of the layers has a thickness of between 0.1 and 1 mm.

76. (Previously Presented) The microstructure architecture of claim 6 comprising at least three layers with a fuel vaporizer and at least two heat exchanger layers.

77. (Previously Presented) The process of claim 35 comprising a first stage and a second stage, wherein the first stage and the second stage contain the same unit operations; and

wherein the first stage contains a number, n, of plural cells operating in parallel, and

wherein the second stage accomplishes a separation with fewer cells operating in parallel.

78. (Previously Presented) A method of conducting unit operations in microcomponent apparatus comprising:

performing a first unit operation on a first stream in a first microcomponent cell, subsequent to the first unit operation, performing a second, discrete unit operation on the first stream to make a first modified stream, then in a second microcomponent cell, performing the first unit operation on the first modified stream, to accomplish a single unit operation for the same purpose as the a first unit operation on the first stream;

wherein the method further comprises passing a second stream through a third microcomponent cell and conducting a third unit operation on the second stream and subsequently passing the second stream into the first microcomponent cell and, simultaneous with the step of performing a first unit operation on a first stream in a first microcomponent cell, performing a unit operation on the second stream in the first microcomponent cell to make a modified second stream;

passing the modified second stream into the third microcomponent cell and conducting a unit operation on the modified second stream in the third microcomponent cell;

passing a third stream through a fourth microcomponent cell and conducting the third unit operation on the third stream and subsequently passing the third stream into the second microcomponent cell and, simultaneous with the step of performing a first unit operation on a first modified stream in the second microcomponent cell, performing a unit operation on the third stream in the second microcomponent cell to make a modified third stream; and

passing the modified third stream into the fourth microcomponent cell and conducting a unit operation on the modified third stream in the fourth microcomponent cell.

79. (Previously Presented) The method of claim 78 further comprising:

subsequent to the step of performing the first unit operation on the first modified stream, performing the second unit operation on the first modified stream to make a second modified stream.

80. (Previously Presented) The method of claim 78 wherein the third microcomponent cell comprises a first recuperator and wherein the fourth microcomponent cell comprises a second recuperator;

wherein the unit operation in the first recuperator comprises heat exchange between the second stream and the modified second stream; and

wherein the unit operation in the second recuperator comprises heat exchange between the third stream and the modified third stream.

81. (Previously Presented) The method of claim 80 wherein the third unit operation comprises heat exchange and wherein the recuperator has a thermal power density of at least 0.6 W per cubic centimeter and an exergetic efficiency of at least 85%.

82. (Previously Presented) The method of claim 78 where the first stream comprises a heat exchange fluid and the first unit operation in a microcomponent cell comprises heat exchange, with heat being transferred from the first stream to provide heat for an endothermic process;

wherein the second unit operation modifying first stream comprises reheating said first fluid by reheating from a heat source or by adding additional fuel or oxygen and performing combustion reactions.

83. (Previously Presented) The method of claim 82 where the endothermic process is an endothermic chemical reaction.

84. (Previously Presented) The method of claim 82 where the endothermic process comprises a drying or desorption process.

85. (Previously Presented) The method of claim 82 where the endothermic process comprises boiling or evaporation.

86. (Previously Presented) The process of claim 78 where the first stream is comprised of chemical reactants and the first unit operation in a microcomponent cell comprises a chemical conversion reaction;

wherein the second unit operation modifying first stream comprises mass transfer, with at least one original reactant being added to the first stream.

87. (Previously Presented) The process of claim 86 where the chemical reaction in first unit operation comprises steam reforming of hydrocarbons, and the second unit operation comprises adding additional hydrocarbon reactant to first stream.